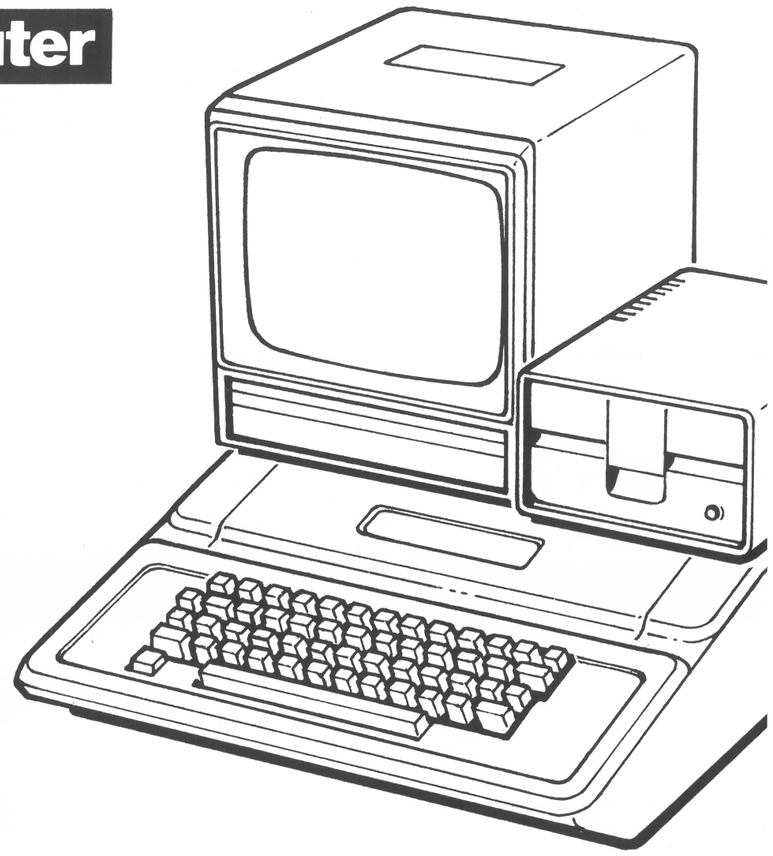
E.M.E

microcomputer program



WATER POLLUTION

Programmed

by

Michael Harmon

Irvington High School
Irvington, New York

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EDUCATIONAL MATERIALS AND EQUIPMENT COMPANY

POST OFFICE BOX 17 • PELHAM, N. Y. 10803

OVERVIEW

WATER POLLUTION is an interactive computer simulation consisting of two parts:

1. Introduction -- reviews the basics of water pollution including physical properties of water, factors affecting dissolved oxygen levels, types of water pollution, fish-kills, biochemical oxygen demand, primary and secondary water treatment.

2. Experiment Mode -- setting up and running water pollution experiments.

In the Experiment Mode, students manipulate the variables which influence water quality. Results are displayed in tables and graphs. A student lab booklet provides basic activities to acquaint all students with various aspects of water pollution, as well as advanced activities to challenge brighter students. If possible, run the program in advance to see what your students will encounter. Prior coverage of water pollution topics reviewed in the program's introduction is recommended.

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OBJECTIVES

The WATER POLLUTION Program will help students to:

1. understand the variables that improve and degrade water quality
2. determine the impact of water pollution on aquatic populations
3. predict the effects of manipulating one or more variables
4. improve data interpretation, problem-solving skills and graphing skills
5. evaluate hypotheses in light of experimental results
6. design experiments and plan a research project

BACKGROUND

Water is a most precious resource. Living things, themselves about 70% water, depend upon water as a medium and reactant for biochemical reactions, for support and for

circulation. In addition, humans use this natural resource for industrial and home use, sanitation, agriculture, recreation and to produce power.

Water is a stable molecule composed of two atoms of hydrogen to every one atom of oxygen. At sea level it vaporizes at 100°C (212°F) and freezes at 0°C (32°F). Water is most dense at 4°C (39.2°F). During the spring and fall, as water approaches this temperature, it displaces water at lower levels. This mixes the body of water, aerating it and bringing nutrients to the surface. In the winter colder but less dense ice forms at the surface protecting organisms overwintering in the bottom waters.

Many useful substances such as oxygen, carbon dioxide and minerals, as well as potentially harmful industrial chemicals and pesticides, dissolve in water. Dissolved oxygen in water results from the photosynthesis reaction in aquatic plants as well as water-surface/atmosphere interactions. Generally, the more turbulent the water, the more dissolved oxygen it can capture from the atmosphere. Cooler water temperatures also increase the levels of dissolved oxygen in a body of water.

Dissolved oxygen levels are also dependent on the rate of decomposition of organic material. As bacteria break organic material into a stable, inorganic form, they use up dissolved oxygen. The amount of oxygen needed for decomposition is called the Biochemical Oxygen Demand (BOD) and is used as an indicator of the "health" of a body of water. A high BOD indicates a high level of organic matter and an "unhealthy" condition. When dissolved oxygen levels become very low, decomposition may occur anaerobically (without oxygen). Noxious gases such as hydrogen sulfide and methane, as well as a foul appearance are characteristic of this condition.

Humans use waterways for disposal of their sewage and industrial wastes, generally reducing dissolved oxygen levels. As the levels approach 5 ppm at about 10°C (50°F), most game fish begin to suffer respiratory distress. Fish will tend to increase their respiratory rate (using up dissolved O_2 faster), while getting 5-10% less

oxygen as water passes through their gills at the faster rate. When dissolved oxygen levels drop below 5 ppm a fishkill results.

Water treatments are used to keep BOD levels low and dissolved oxygen at levels adequate to support aquatic communities. Primary water treatment involves passing water through a coarse screen, a grit chamber and a sedimentation tank to remove heavy, solid waste. This process alone reduces BOD by 35-40%. Secondary water treatment destroys harmful organisms and removes some dissolved materials. This can be done in one of two ways. The Trickling Filter Method passes water over crushed stone (1.5m deep), which captures a film of microorganisms. The film combines with oxygen and changes harmful substances into a form that can be filtered out in a sedimentation tank. Addition of chlorine further purifies the water. Remaining sludge is treated and can be recycled as fertilizer, but more frequently is dumped into the ocean. The Activated Sludge Method of secondary water treatment uses bacteria which, together with oxygen, destroys harmful microorganisms. Primary and secondary treatment combined can reduce BOD by 80-90%.

EXPERIMENTAL VARIABLES

The WATER POLLUTION Program calculates dissolved oxygen and waste concentration levels under a variety of conditions. The model displays results by means of a data table and a graph that plots both dissolved oxygen levels and waste concentration against time.

Students can manipulate the following variables:

1. Body of water (Pond,Lake,Slow or Fast Rivers)
2. Water temperature (1^{o}- 32^{o}C)
3. Type of Waste (Industrial,Sewage)
4. Dumping rate (0-14 ppm/day)
5. Type of treatment (None,Primary,Secondary)
6. Number of days (2 - 30)

To change a variable: Type 1 (Modify Specs) and press RETURN. The computer shows the previous set of data used and displays each variable one at a time to allow for

modifications. To change a variable, type in the new value and press RETURN. To keep a value, just type RETURN.

To return to the Specifications and Options Index: Press RETURN if at the end of a run. Otherwise press CONTROL and RESET simultaneously and type RUN. The Specifications will display the value of each variable from the previous run. The Options Index, also displayed, allows the student to select any of the following forms of output: display table, display plot, or print table.

OUTPUT OPTIONS

To see table of waste concentration and dissolved oxygen levels for each day: Type 2 (Display Table) and press RETURN. Levels are indicated in parts per million (ppm). When dissolved oxygen levels are less than 5 ppm, FISHKILL is flashed on the screen.

To see graphs plotting dissolved oxygen level and waste concentration vs. days: Type 3 (Display Plot) and press RETURN. The computer plots the dissolved oxygen level in red using the left vertical axis and the waste level in blue using the right vertical axis. Variable values for body of water, temperature, dumping rate, type of waste and treatment are listed above graph.

To obtain hard copy output of the data: Type 4 (Print Table) and press RETURN. If a printer is attached, this option prints a paper copy of the data table. (Note: Before executing this option, the program asks if a printer is attached. If Y is entered, the program asks for the slot number -- normally 1 -- where the printer is attached. Enter the slot number to start the printer output.)

To end a session: Return to the Options Index, type 6 (Quit) and press RETURN. The computer gives a goodbye message and offers the option to return to the Introduction or the Experiment Mode. If finished, remove the diskette from the disc drive and turn off power.

To restart the program: If there is a delay of more than 30 seconds, press CONTROL and C at the same time, then type PR #6 and press RETURN. If this fails turn off power, wait 3 seconds and then turn power on again.

STUDENT ACTIVITIES

1. Testing Water Samples for Dissolved Oxygen Levels

Methylene blue is an indicator which changes water color from a deep blue in an oxygen-rich environment to colorless in an oxygen-poor environment. Collect a small bottle of mid-depth water from several local waterways (pond, river, stream, bay or lake). DO NOT COLLECT SEWAGE WATER, as it can be a source of disease. Pour 10ml of each water sample into separate test tubes and mix well with 2ml of methylene blue. Use a stopwatch to record the length of time required to produce a color change. Repeat this procedure for each sample. Compare results for each site.

A) How long does it take for a color change to occur in each sample?

B) Which sample has the highest level of dissolved oxygen? How do you know?

C) Which sample has the highest BOD? How do you know?

2. Effects of Temperature and Dissolved Oxygen on Fish Respiratory Rates

Hardy, freshwater tropical fish, such as large swordtails, angelfish or platys, can be used for this experiment. The optimum temperature for freshwater tropical fish is between 22°C (72°F) and 27°C (80°F). As temperature increases, the amount of dissolved oxygen that the water can hold decreases. Fish attempt to compensate for the lower amount of dissolved oxygen by increasing their respiratory rate. Locate the gill covers of your fish, just in front of the pectoral fins. Count the number of movements of the gill covers per minute (use 15-second intervals and multiply by 4) at the following temperatures: 18°C (65°F), 21°C (70°F), 24°C (75°F), 27°C (80°F), 29°C (85°F). (NOTE: Slowly manipulate the temperature of the fish container over a 15-minute period to achieve the desired temperature. Sudden temperature changes may produce shock and kill the fish.) Perform this test at each temperature at least three times and then average your results for accuracy. Graph the number of gill movements against temperature. What trends in respiratory rate can you notice?

3. Local Investigations

Locate sources of industrial, agricultural or sewage water pollution in your area. Find out how much of each type of waste must be dealt with daily and the problems it presents. Determine how local authorities regulate water pollution and how they enforce these regulations.

4. Arrange a Tour of the Local Sewage Treatment Plant

Collect first-hand information on primary and secondary water treatment technology. Prepare a report summarizing your findings.

GLOSSARY

Biochemical Oxygen Demand (BOD): the amount of oxygen required in a body of water to decompose its organic waste content.

Decomposition: the biochemical breakdown of organic materials into stable, inorganic compounds by bacteria and fungi. This process may be done aerobically (with oxygen) or anaerobically (without oxygen).

Fishkill: less than 5 ppm of dissolved oxygen at 10°C (50°F) results in the death of large numbers of game fish such as trout.

Industrial waste: from factories, mines, research facilities, etc.; includes salts, acids, oils, tars, greases and heavy metals.

Pollution: the undesirable alteration of the environment through human activities.

Primary Waste Treatment: removes heavy, solid waste materials through filtering; this process reduces the BOD by 35-40%.

Secondary Waste Treatment: destroys harmful microorganisms and removes certain dissolved materials by means of bacterial action. Reduces BOD by 80-90% when coupled with primary waste treatment.

Sewage: organic plant, animal, and human wastes.

Sludge: semiliquid waste resulting from sewage purification.

Solubility: the ability to dissolve.